On the Relative Rectilinear Motion of the Components of 61 *Cygni.*

By J. M. Wilson, Esq., M.A.

I have lately examined into the relative motion of the components of 61 *Cygni*, with the intention of ascertaining how far recent measures confirm Struve's conclusion that this motion is rectilinear. The very great common proper motion of these stars, that of one being given by Struve as $517'' \pm 10''$ per century in the direction $51° 16' \pm 1°$, and that of the other as $509'' \pm 10''$ in the direction $53° 38' \pm 1°$, gives an enormous probability to the hypothesis that these stars are physically connected. Struve computed it arithmetically, and concludes with the words, "nexus itaque physicus inter stellas 61 *Cygni* plus centies millies est probabilior, quam crastinus Solis ortus secundum experientiam historicam plus quinque millium annorum exspectandus."

But on examining into the observations on the relative distance and position of these stars from the year 1753 to 1851, he found that they were adequately represented by motion in a *straight line*. His words are, "Consensus, qui inter relationes observatas et eas, quæ calculo deductæ sunt, obtinet, talis est, ut nullus dubito quin declarem, motum relativum duarum stellarum in 61 *Cygni* nexarum ne minimam quidem a linea recta deflexionem quæ in observationibus cognosci posset, centum annorum spatio prodidisse. Res sane maximopere mirabilis mihique valde inexspectata."

In the following investigation, have made use of all the measures accessible to me, most of which were kindly sent by my friend Mr. Gledhill. They include a large number of observations since 1851, and many also before 1851 which Struve did not use; as he appears to have employed, for the years 1828 to 1851 only his own observations. In using these measures there is no certain method of deciding what weights ought to be given to the measures. I have, however, given great weight to Struve's measures from 1819 to 1836, then Dawes and Mädler become the principal authorities till 1854, and latterly Dembowski who measured this star with very great care on many nights, and at the present time Gledhill and Main.

The position and distance in 1753, &c., are to be calculated from Bradley's observations, that

$$\Delta\alpha = 14''\cdot4 \pm 1'' \text{ and } \Delta\delta = 15''\cdot7 \pm 1''.$$

The former of these is the mean of only two observations, 15″, and 13″ 8, and the latter is a single observation. These give an angle of $36° 0' \pm 3° 40'$, and the distance at the same time is $19''\cdot40$, with a considerable probable error.

The annexed table gives all the measures with which I am acquainted, and for comparison the places computed on the hypothesis of the uniform relative rectilinear motion along a line

whose equation (referred to axes passing through the principal star, the axis of x being the declination circle of the epoch 1870, which is the zero of angle, and that of y in the direction 90°) is

$$y = x \tan 166^\circ\ 58' + 15{\cdot}60.$$

The places are calculated for A.D. τ from the formula

$$\tan\theta = \frac{y}{x} = \frac{12{\cdot}1664 + {\cdot}04292\ (\tau - 1750)}{14{\cdot}8336 - {\cdot}18542\ (\tau - 1750)}$$

$$r = y \operatorname{cosec}\theta.$$

It will be observed that the effect of precession has to be taken into account, and that a correction has to be applied to all the observations of position to bring them up to the epoch 1870.

Date.	θ° Obs.	θ° Corr.	θ_1° Calc.	$\theta_1-\theta^\circ$	r'' Obs.	r_1'' Calc.	$r_1''-r''$	
1753·8	36·00 ±	35·42 ±	41·11	+5·69	19·41 ±	18·75	− ·66	Bradley
78·7	51·0 ±	50·55 ±	54·62	+4·07	15·27 ±	16·43	+1·16	Mayer
81·9	53·81	53·37	56·62	+3·25	16·33	16·21	− ·12	Herschel
1802·3	74·36 ±	74·02 ±	70·38	−3·64	16·8 ±	15·30	−1·5	Piazzi
06·3	67·54 ±	67·22 ±	73·23	+6·01	14·85 ±	15·63	+ ·78	,,
12·3	79·11	78·82	77·52	− ·96	16·74	15·20	−1·54	Bessel
19·92	82·96	82·72	82·98	+ ·26	15·20	15·28	+ ·08	Σ
21·62	84·38	84·14	84·18	+ ·04	15·02	15·32	+ ·30	Σ
22·9	84·68	84·44	85·08	+ ·64	15·42	15·36	− ·06	H & S
25·7	86·93	86·71	87·04	+ ·33	15·44	15·43	− ·01	S
28·72	89·40	89·19	89·20	+ ·01	15·31	15·55	+ ·24	Σ
30·64	90·33	90·13	90·43	+ ·30	15·70	15·63	− ·07	Dawes
·84	90·35	90·15	90·57	+ ·42	15·63	15·64	+ ·01	Σ
31·74	91·16	90·97	91·18	+ ·25	15·63	15·68	+ ·05	Σ
·74	90·70	90·51	91·18	+ ·67	15·45	15·68	+ ·23	H
32·57	90·91	90·72	91·75	+1·03	...	...	...	H
·77	92·05	91·86	91·88	+ ·02	15·79	15·73	− ·06	Σ
33·80	92·78	92·60	92·57	− ·03	15·88	15·78	− ·10	Dawes
35·65	93·83	93·66	93·79	+ ·13	15·96	15·88	− ·08	Σ
36·57	94·41	94·24	94·38	+ ·14	16·08	15·93	− ·15	Σ
37·63	95·15	94·99	95·07	+ ·08	16·27	15·97	− ·30	Encke
·71	95·45	95·29	95·12	− ·17	15·91	15·97	+ ·06	Galle
38·38	95·32	95·16	95·55	+ ·39	16·20	16·03	− ·17	Bessel
·73	96·06	95·90	95·78	− ·12	16·76	16·05	− ·71	Galle

Date.	θ° Obs.	θ° Corr.	θ_1° Calc.	$\theta_1-\theta$°	r'' Obs.	r_1'' Calc.	$r_1''-r''$	
1840·05	97·10	96·95	96·63	− ·32	16·01	16·14	+ ·13	Kaiser
·73	97·25	97·10	97·06	− ·04	16·4	16·19	− ·21	Dawes
41·49	98·53	98·38	97·55	− .83	16·49	16·24	− ·25	Mädler
·87	97·94	97·79	97·78	− ·01	16·55	16·26	− ·29	Dawes
42·62	99·03	98·89	98·24	− ·65	16·86	16·33	− ·53	Mädler
43·64	99·51	99·38	98·89	− ·49	16·5	16·39	− ·1	„
·76	98·90	98·77	98·96	+ ·19	16·78	16·39	− ·39	Dawes
·98	99·69	99·56	99·11	− ·45	...	...	...	„
44·34	99·42	99·29	99·32	+ ·03	16·68	16·44	− ·24	OΣ
·48	100·10	99·97	99·40	− ·57	16·35	16·45	+ ·10	Mädler
45·06	99·86	99·74	99·75	+ ·01	16·36	16·48	+ ·12	„
46·07	100·97	100·85	100·37	+ ·48	17·07	16·56	− ·51	Dawes
48·07	99·8	99·69	101·56	+ 1·96	16·4	16·70	+ ·3	Smyth
·30	101·95	101·84	101·70	− ·14	17·0	16·73	− ·27	Dawes
·49	101·47	101·36	101·81	+ ·45	17·11	16·74	− ·37	OΣ
50·88	103·87	103·77	103·19	− ·58	17·04	16·93	− ·11	Dawes
·94	103·06	102·96	103·24	+ ·28	16·79	16·94	+ ·17	Mädler
51·81	103·67	103·58	103·74	+ ·16	17·32	17·03	− ·29	OΣ
·90	103·66	103·57	103·79	+ ·21	16·90	17·03	+ ·13	Mädler
52·68	104·69	104·60	104·23	− ·37	17·11	17·10	− ·01	Mädler
·76	104·30	104·23	104·27	+ ·04	17·40	17·11	− ·29	Jacob
53·13	104·45	104·36	104·48	+ ·12	16·90	17·13	+ ·23	Mädler
·26	104·39	104·30	100·55	+ ·25	17·24	17·14	− ·10	Dawes
·80	103·70	103·62	104·87	+ 1·25	17·0	17·20	+ ·2	Smyth
·89	104·73	104·65	104·92	+ ·27	17·68	17·20	− ·48	Jacob
·94	104·85	104·77	104·95	+ ·18	17·28	17·21	− ·07	Mädler
54·55	105·02	104·94	105·28	+ ·34	17·63	17·26	− ·37	Mädler
·73	105·58	105·50	105·38	− ·12	17·29	17·28	− ·01	Dembowski
·98	105·69	105·61	105·52	− ·09	17·29	17·30	+ ·01	„
55·55	105·60	105·53	105·87	+ ·34	17·50	17·36	− ·14	Secchi
·99	105·9	105·83	106·09	+ ·26	17·94	17·40	− ·54	„
56·63	105·2	105·13	106·44	+ 1·31	17·89	17·46	− ·43	„
57·59	107·86	107·80	106·95	− ·85	17·62	17·55	+ ·07	Dembowski
62·97	109·50	109·47	109·76	+ ·29	18·36	18·08	− ·28	„
65·15	110·64	110·62	110·85	+ ·23	18·55	18·31	− ·24	„
65·75	109·7	109·68	111·15	+ 1·47	...	...	...	Talmage
·76	111·3	111·28	111·15	− ·13	18·75	18·36	− ·37	„
66·73	112·8	112·78	111·62	− 1·16	18·81	18·49	− ·32	„

Date.	θ° Obs.	θ° Corr.	θ_1° Calc.	$\theta_1-\theta$°	r'' Obs.	r_1' Calc.	$r_1''-r''$	
1866·84	111·8	111·78	111·63	− ·15	18·84	18·49	− ·35	Secchi
67·16	111·78	111·77	111·83	+ ·06	18·73	18·52	− ·21	Dembowski
68·60	112·32	112·32	112·51	+ ·20	18·70	18·70	− ·00	Main
69·28	113·27	113·27	112·83	− ·44	18·91	18·76	− ·15	Dembowski
·58	112·31	112·31	112·97	+ ·66	18·65	18·79	+ ·14	Main
70·49	112·37	112·37	113·40	+ 1·03	19·27	18·90	− ·37	„
·53	113·9	113·9	113·41	− ·49	19·15	18·90	− ·25	Gledhill
71·50	114·08	114·09	113·87	− ·22	19·27	19·02	− ·25	„
72·72	113·6	113·61	114·43	+ ·82	18·93	19·15	+ ·18	Talmage
·73	114·45	114·46	114·43	− ·02	19·00	19·15	+ ·15	Wilson
·78	114·15	114·16	114·44	+ ·28	19·77	19·16	− ·61	Main
73·05	114·59	114·60	114·55	− ·05	19·38	19·19	− ·19	Dembowski
·75	114·97	114·99	114·88	− ·11	19·36	19·26	− ·10	Gledhill
74·92	115·4	115·42	115·43	+ ·01	19·52	19·41	− ·11	„

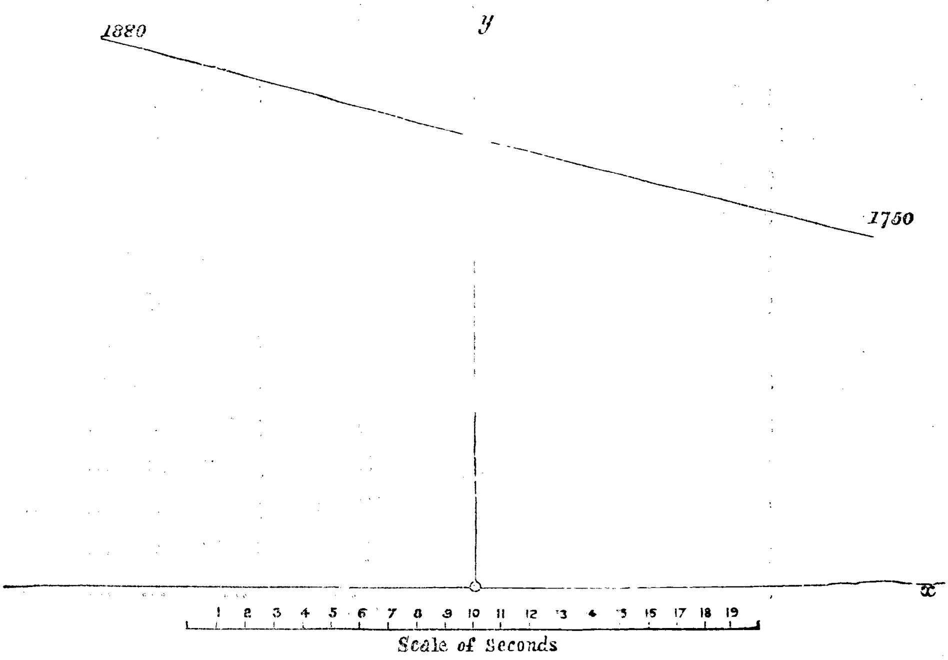
It must be observed that in the above calculation the observations of angles were allowed more weight than those of distances, it being difficult, as is shown by the discordant observations, to determine the distance of a 19″ star within 0″·1, or even 0″·2. And further, no weight was attached to early observations previous to 1819. The methods adopted were partly graphical, partly analytical. The conclusions, therefore, that seem to follow from the table, are as follow: the hypothesis of uniform rectilinear motion satisfies the observation of *angle* during the present century with sufficient accuracy, but it makes the *distances* a little less than the observed distances during the last 25 years. But this hypothesis fails to satisfy the observations of the last century with fair accuracy, the errors increasing in earlier observations, and Struve's hypothesis fails equally to satisfy present observations.

The result obtained by Struve from a discussion of the most probable result of the early measures combined with his own was, that the motion was in a straight line, which had a minimum distance of 14″·74 in 1805·35 in the direction 71° 28′, and my line has a minimum distance of 15″·19 in 1811·58 in the direction of 76° 58′. The combination of these would indicate that the motion has deviated slightly from rectilinearity, the earlier described portions of the path being inclined to the later portions at an angle of about 5° 30′, and making the whole path concave to the principal star. But this conclusion rests almost entirely on the first three observations of the list, and must, therefore, be accepted with some hesitation.

What is certain is, that the motion deviates extremely little from rectilinearity, considering that so large an angle has now

been described. The star ought to be measured repeatedly with great care, and with the best instruments, for some years to come, and then the question of its motion may be advantageously re-discussed.

A diagram is annexed to show the path that has been at present described.



Temple Observatory, Rugby,
1875, *March.*

Observations of the Satellites of Saturn made in 1874 at the Washington Observatory.

(*Communicated by the Director of the Observatory.*)

In the column "No." the figure denotes either the number of independent measures of position-angle, or the number of measures of double distance. In the column "wt." the number denotes the goodness of the images on a scale from 5 = perfect to 1 = very bad. In the column "Obser." N denotes Newcomb and H Holden.

The value of 1 revolution of the micrometer-screw is $9''\cdot9482 \pm 0''\cdot0049$.